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Lavoie

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(54) **HITCH ANGLE MONITORING SYSTEM AND METHOD**

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(51) **Int. Cl.**

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(52) **U.S. Cl.**

CPC ................ ***B62D 13/06*** (2013.01); ***B60R 1/003*** (2013.01); ***B60W 30/00*** (2013.01); ***H04N 7/183*** (2013.01); *B60R 2300/806* (2013.01)

(58) **Field of Classification Search**

CPC .. B62D 13/06; B60R 1/003; B60R 2300/806; H04N 7/183

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See application file for complete search history.

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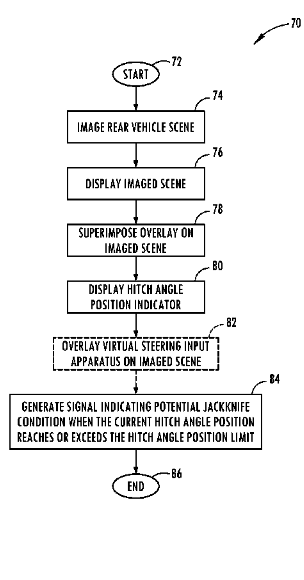
(57) **ABSTRACT**

A hitch angle monitoring system and method are provided. A display shows an imaged scene of a hitch connection between a tow vehicle and a trailer. A processor is configured to superimpose an overlay on the imaged scene, wherein the overlay indicates a hitch angle position limit. A hitch angle position indicator is shown on the display and visually relates a current hitch angle position to the hitch angle position limit.

**20 Claims, 4 Drawing Sheets**



## Related U.S. Application Data

14/289,888, filed on May 29, 2014, which is a continuation-in-part of application No. 14/256,427, filed on Apr. 18, 2014, said application No. 14/294,489 is a continuation-in-part of application No. 14/257,420, filed on Apr. 21, 2014, which is a continuation-in-part of application No. 14/256,427, filed on Apr. 18, 2014, which is a continuation-in-part of application No. 14/249,781, filed on Apr. 10, 2014, which is a continuation-in-part of application No. 14/188,213, filed on Feb. 24, 2014, which is a continuation-in-part of application No. 13/847,508, filed on Mar. 20, 2013, and a continuation-in-part of application No. 14/068,387, filed on Oct. 31, 2013, now Pat. No. 9,102,271, which is a continuation-in-part of application No. 14/059,835, filed on Oct. 22, 2013, which is a continuation-in-part of application No. 13/443,743, filed on Apr. 10, 2012, now Pat. No. 8,825,328, which is a continuation-in-part of application No. 13/336,060, filed on Dec. 23, 2011, now Pat. No. 8,909,426, said application No. 14/249,781 is a continuation-in-part of application No. 14/161,832, filed on Jan. 23, 2014, which is a continuation-in-part of application No. 14/059,835, filed on Oct. 22, 2013, said application No. 14/249,781 is a continuation-in-part of application No. 14/201,130, filed on Mar. 7, 2014, which is a continuation-in-part of application No. 14/068,387, filed on Oct. 31, 2013, now Pat. No. 9,102,271.

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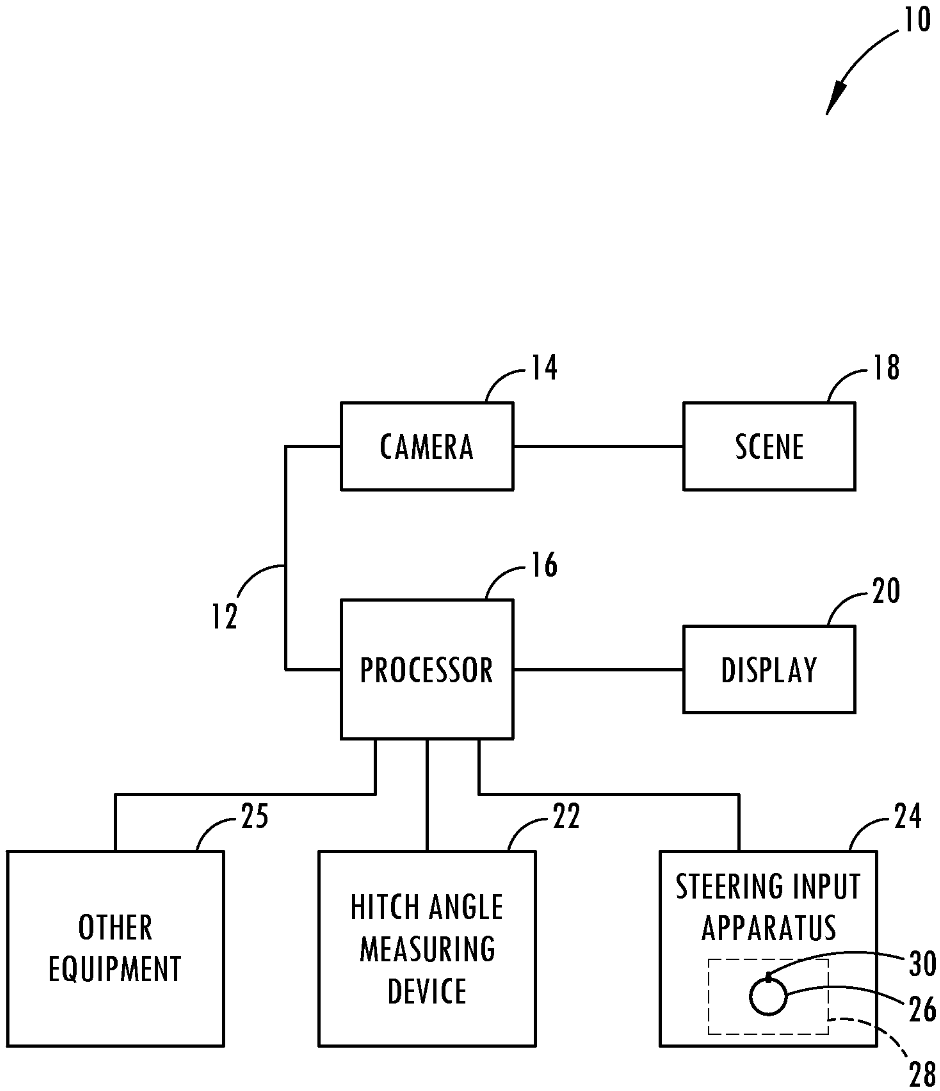
10
14
CAMERA
18
SCENE
12
16
PROCESSOR
20
DISPLAY
25
OTHER EQUIPMENT
22
HITCH ANGLE MEASURING DEVICE
24
STEERING INPUT APPARATUS
30
26
28

FIG. 1

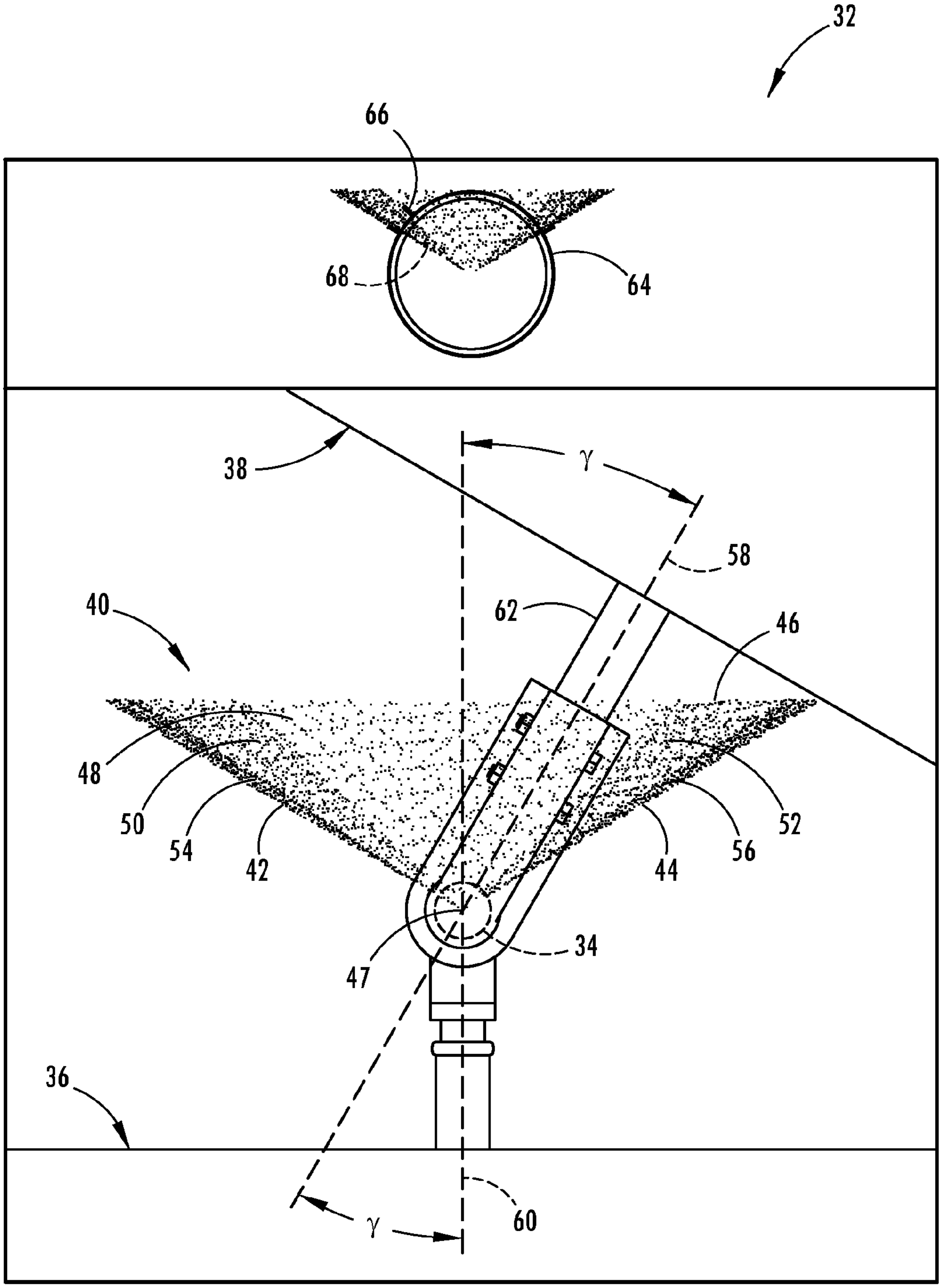


FIG. 2

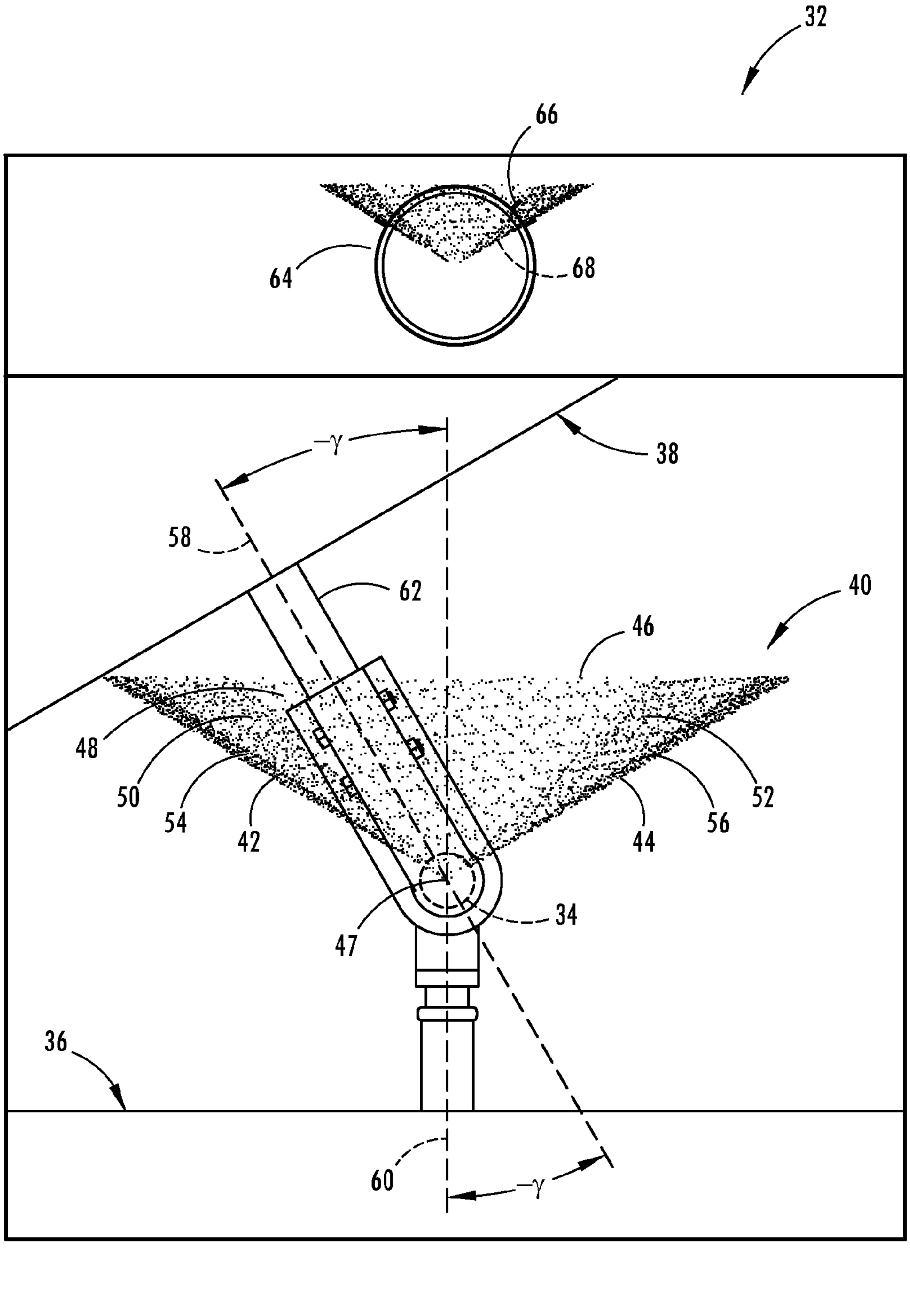


FIG. 3

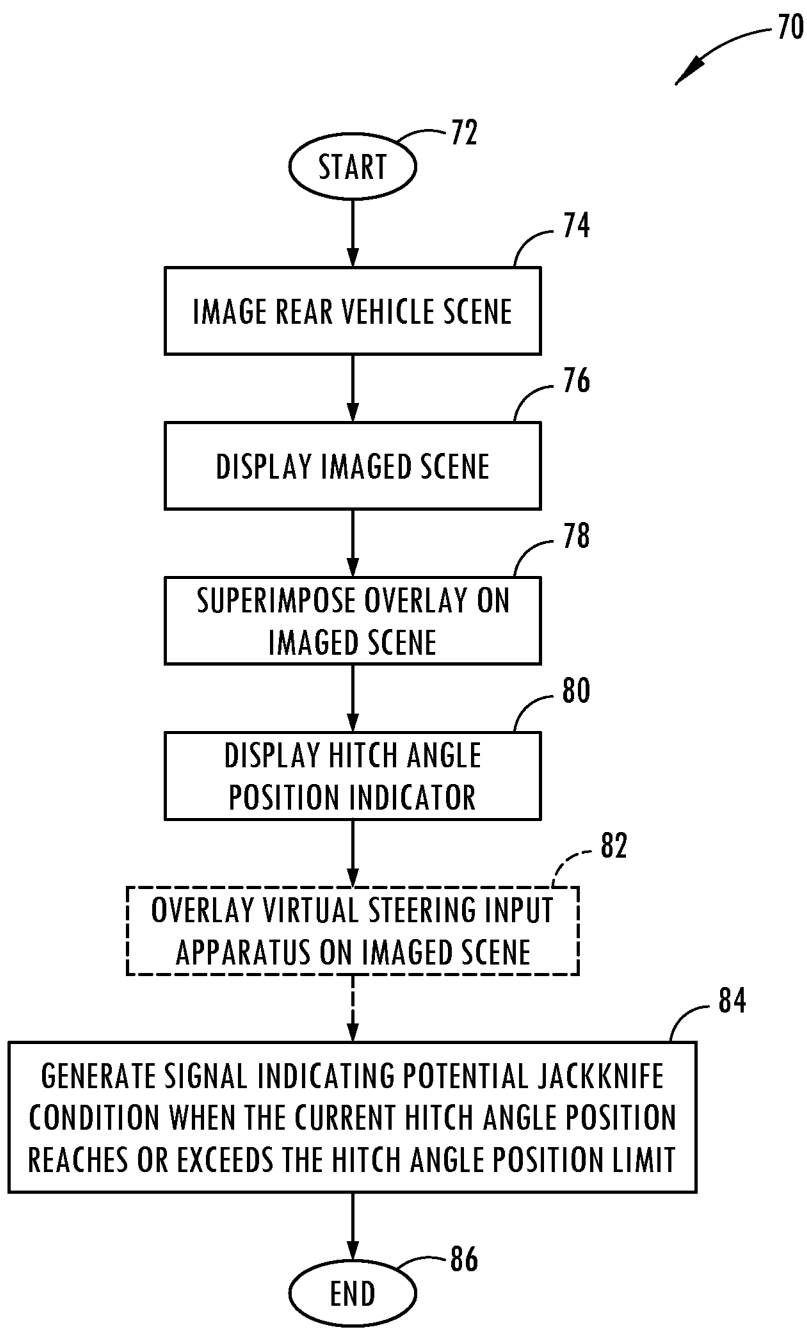
70
72
START
74
IMAGE REAR VEHICLE SCENE
76
DISPLAY IMAGED SCENE
78
SUPERIMPOSE OVERLAY ON IMAGED SCENE
80
DISPLAY HITCH ANGLE POSITION INDICATOR
82
OVERLAY VIRTUAL STEERING INPUT APPARATUS ON IMAGED SCENE
84
GENERATE SIGNAL INDICATING POTENTIAL JACKKNIFE CONDITION WHEN THE CURRENT HITCH ANGLE POSITION REACHES OR EXCEEDS THE HITCH ANGLE POSITION LIMIT
86
END

FIG. 4

# HITCH ANGLE MONITORING SYSTEM AND METHOD

## CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a continuation-in-part of U.S. patent application Ser. No. 14/301,919 which was filed on Jun. 11, 2014, entitled "TRAILER LENGTH ESTIMATION IN HITCH ANGLE APPLICATIONS" which is a continuation-in-part of U.S. patent application Ser. No. 14/294,489, which was filed on Jun. 3, 2014, entitled "TRAILER LENGTH ESTIMATION IN HITCH ANGLE APPLICATIONS," which is a continuation-in-part of U.S. patent application Ser. No. 14/289,888, which was filed on May 29, 2014, entitled "DISPLAY SYSTEM UTILIZING VEHICLE AND TRAILER DYNAMICS," which is a continuation-in-part of U.S. patent application Ser. No. 14/256,427, which was filed on Apr. 18, 2014, entitled "CONTROL FOR TRAILER BACKUP ASSIST SYSTEM." U.S. patent application Ser. No. 14/294,489 is also a continuation-in-part of U.S. patent application Ser. No. 14/257,420 which was filed on Apr. 21, 2014, entitled "TRAJECTORY PLANNER FOR A TRAILER BACKUP ASSIST SYSTEM," which is a continuation-in-part of U.S. patent application Ser. No. 14/256,427, which was filed on Apr. 18, 2014, entitled "CONTROL FOR TRAILER BACKUP ASSIST SYSTEM," which is a continuation-in-part of U.S. patent application Ser. No. 14/249,781, which was filed on Apr. 10, 2014, entitled "SYSTEM AND METHOD FOR CALCULATING A HORIZONTAL CAMERA TO TARGET DISTANCE," which is a continuation-in-part of U.S. patent application Ser. No. 14/188,213, which was filed on Feb. 24, 2014, entitled "SENSOR SYSTEM AND METHOD FOR MONITORING TRAILER HITCH ANGLE," which is a continuation-in-part of U.S. patent application Ser. No. 13/847,508, which was filed on Mar. 20, 2013, entitled "HITCH ANGLE ESTIMATION." U.S. patent application Ser. No. 14/188,213 is also a continuation-in-part of U.S. patent application Ser. No. 14/068,387, which was filed on Oct. 31, 2013, entitled "TRAILER MONITORING SYSTEM AND METHOD," which is a continuation-in-part of U.S. patent application Ser. No. 14/059,835, which was filed on Oct. 22, 2013, entitled "TRAILER BACKUP ASSIST SYSTEM," which is a continuation-in-part of U.S. patent application Ser. No. 13/443,743 which was filed on Apr. 10, 2012, entitled "DETECTION OF AND COUNTERMEASURES FOR JACKKNIFE ENABLING CONDITIONS DURING TRAILER BACKUP ASSIST," which is a continuation-in-part of U.S. patent application Ser. No. 13/336,060, which was filed on Dec. 23, 2011, entitled "TRAILER PATH CURVATURE CONTROL FOR TRAILER BACKUP ASSIST," which claims benefit from U.S. Provisional Patent Application No. 61/477,132, which was filed on Apr. 19, 2011, entitled "TRAILER BACKUP ASSIST CURVATURE CONTROL." U.S. patent application Ser. No. 14/249,781 is also a continuation-in-part of U.S. patent application Ser. No. 14/161,832 which was filed Jan. 23, 2014, entitled "SUPPLEMENTAL VEHICLE LIGHTING SYSTEM FOR VISION BASED TARGET DETECTION," which is a continuation-in-part of U.S. patent application Ser. No. 14/059,835 which was filed on Oct. 22, 2013, entitled "TRAILER BACKUP ASSIST SYSTEM." Furthermore, U.S. patent application Ser. No. 14/249,781 is a continuation-in-part of U.S. application Ser. No. 14/201,130 which was filed on Mar. 7, 2014, entitled "SYSTEM AND METHOD OF CALIBRATING A TRAILER BACKUP ASSIST SYSTEM," which is a continuation-in-part of U.S. patent application Ser. No. 14/068,387, which was filed on Oct. 31, 2013, entitled "TRAILER MONITORING SYSTEM AND METHOD." The aforementioned related applications are hereby incorporated by reference in their entirety.



## FIELD OF THE INVENTION

The disclosure made herein generally relates to driver assist technologies in vehicles, and more particularly to hitch angle monitoring that may be used in conjunction with a trailer backup assist system.

## BACKGROUND OF THE INVENTION

Reversing a vehicle while towing a trailer is very challenging for many drivers. If a hitch angle between a tow vehicle and trailer becomes sufficiently large, a potential jackknife condition may result. Thus, there is a need for a hitch angle monitoring system that allows a driver to identify when a hitch angle between a tow vehicle and a trailer is approaching a suggested limit so as to avoid a potential jackknife condition.

## SUMMARY OF THE INVENTION

According to one aspect of the present invention, a hitch angle monitoring system is provided. The system includes a display for showing an imaged scene of a hitch connection between a tow vehicle and a trailer. A processor is configured to superimpose an overlay on the imaged scene, wherein the overlay indicates a hitch angle position limit. A hitch angle position indicator is shown on the display and visually relates a hitch angle position to the hitch angle position limit.

According to another aspect of the present invention, a hitch angle monitoring system is provided. The system includes a display for showing an imaged scene. A processor is configured to superimpose an overlay on the imaged scene that indicates a hitch angle position limit between a tow vehicle and a trailer. A hitch angle position indicator is shown on the display and moves in relation to the hitch angle position limit based on a change in hitch angle between the tow vehicle and the trailer.

According to yet another aspect of the present invention, a hitch angle monitoring method is provided. The method includes the steps of imaging a rear vehicle scene, displaying the imaged scene, superimposing an overlay on the imaged scene that identifies a hitch angle position limit between a tow vehicle and a trailer, and displaying a hitch angle position indicator that identifies a current hitch angle position in relation to the hitch angle limit position.

These and other aspects, objects, and features of the present invention will be understood and appreciated by those skilled in the art upon studying the following specification, claims, and appended drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** shows a block diagram of a hitch angle monitoring system, according to one embodiment;

FIG. **2** is a diagram of an imaged scene showing a tow vehicle and a trailer being backed along a curved path in a clockwise direction;

FIG. **3** is a diagram of an imaged scene showing a tow vehicle and a trailer being backed along a curved path in a counterclockwise direction; and

FIG. **4** is a flow chart of a hitch angle monitoring method, according to one embodiment.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As required, detailed embodiments of the present invention are disclosed herein. However, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to a detailed design and some schematics may be exaggerated or minimized to show function overview. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

As used herein, the term "and/or," when used in a list of two or more items, means that any one of the listed items can be employed by itself, or any combination of two or more of the listed items can be employed. For example, if a composition is described as containing components A, B, and/or C, the composition can contain A alone; B alone; C alone; A and B in combination; A and C in combination; B and C in combination; or A, B, and C in combination.

The disclosed subject matter is directed to a hitch angle monitoring system and method for use with a trailer backup assist (TBA) system. In particular, the system and method enables a driver of a tow vehicle to monitor a current hitch angle position in relation to a hitch angle position limit between a tow vehicle and an attached trailer. The system and method disclosed herein is particularly beneficial when implemented with a trailer backup assist system that utilizes a steering input apparatus to enable the driver of the tow vehicle to control the curvature for the path of travel of the attached trailer.

Referring to FIG. **1** a block diagram of a hitch angle monitoring system **10** is shown. The system **10** includes an imaging module **12** that includes a camera **14** in communication with a processor **16**, both of which may be combined with a trailer backup assist system. The camera **14** can be provided on a tow vehicle in a rear-facing configuration and disposed to image a scene **18** of a hitch connection between the tow vehicle and a trailer. The processor **16** analyzes image data from the camera **14** and may output the imaged scene to a display **20**, which may include an existing display of the trailer backup assist system or other display typically located within the tow vehicle and made visible to the driver. In one embodiment, the processor **16** may prompt the display **20** to automatically show the imaged scene when the tow vehicle has been placed in reverse or is otherwise in a parked position.

As is further shown in FIG. **1**, the processor **16** may be in communication with a hitch angle measuring device **22**, a steering input apparatus **24**, and other equipment **25** related to the tow vehicle or independent thereof. In one embodiment, the processor **16** receives input from the hitch angle measuring device **22**, which may include one or more hitch angle sensors configured to measure the hitch angle between the tow vehicle and trailer and send the hitch angle measurements to the processor **16**. Additionally or alternatively, the hitch angle may be directly measured using the camera module **12**. For example, the camera module **12** may employ object identification techniques in order to image a fixed target located on the trailer (e.g. trailer tongue) and the processor **16** may determine the hitch angle between the tow vehicle and trailer based on the target's location within the imaged scene.

The processor **16** may also receive input from the steering input apparatus **24**, which may be a rotatable or a non-rotatable control input device. For purposes of illustration, the steering input apparatus **24** is shown embodied as a rotatable knob **26** that is angularly disposed in an at-rest position and is coupled to a movement sensing device **28**. The movement sensing device **28** is configured for sensing movement of the knob **26** and outputting a corresponding signal (i.e., movement sensing device signal), which may be sent to the processor **16** and used by the trailer backup assist system to determine a proper wheel steer angle for the tow vehicle. The movement sensing device signal may be generated as a function of an amount of rotation of the knob **26** with respect to the at-rest position, a rate movement of the knob **26**, and/or a direction of movement of the knob **26** with respect to the at-rest position.

The knob **26** may include a steering angle position indicator **30** having a fixed position on the knob **26** and serves as a visual aid identifying the rotational position of the knob **26** when turned relative to the at-rest position. In the illustrated embodiment, the at-rest position may correspond to the angular position of the knob **26** at which the steering angle position indicator **30** is located in the twelve o'clock position and indicates that the tow vehicle will back along a substantially straight path if the knob **26** is left alone. Assuming the tow vehicle and trailer are aligned with one another, the driver may turn the knob **26** either to the left or to the right during a backup maneuver, which causes the tow vehicle and trailer to be backed along a curved path in either a clockwise direction or a counterclockwise direction, respectively. As the knob **26** is turned further in either direction, the hitch angle between the tow vehicle and trailer increases, resulting in an increase in path curvature. Recognizing that trailers of differing dimensions (e.g. trailer length) respond at varying rates to positional changes of the knob **26**, the processor **16** may generate one or more overlays, as described in greater detail below, that are shown on the display **20** to visually assist a driver with manipulating the knob **26** during a backup maneuver.

FIG. **2** shows an imaged scene **32** of a trailer hitch connection **34** between a tow vehicle **36** and a trailer **38**. An overlay **40** is superimposed on the imaged scene **32** and may be configured as an inverted triangle defined by a first boundary line **42**, a second boundary line **44**, and a third boundary line **46**. As shown, the first and second boundary lines **42**, **44** meet at point **47** coinciding with a central area of the imaged trailer hitch connection **34** and extend upward and outwardly therefrom in opposite directions before being joined to an end of the third boundary line **46**, which extends horizontally across the imaged scene **32**. With respect to the illustrated embodiment, the overlay **40** may be separated into a plurality of triangular regions that may include a central region **48**, outer regions **50** and **52**, and outermost regions **54** and **56**. The position and dimensions of the overlay **40** may be determined by the processor **16** based on vehicle related information, camera related information, and/or trailer related information. While the overlay **40** and accompanying regions **48**-**56** have been shown and described herein as being triangular, it should be appreciated that other shapes may be used for accomplishing the same.

According to one embodiment, each region **48**-**56** of the overlay **40** may encompass one or more hitch angle positions, each corresponding to an angular position of a centerline longitudinal axis **58** of the trailer **38** relative to a fixed centerline longitudinal axis **60** of the tow vehicle **36**. Generally, the centerline longitudinal axis **60** of the tow vehicle **36** coincides with the centerline longitudinal axis **58** of the trailer **38** when the tow vehicle **36** is aligned with the trailer **38**, which typically occurs prior to performing a backup maneuver. Subsequently, when a backup maneuver is performed, the hitch angle position tends to be static when the backup maneuver occurs along a straight path or dynamic when the backup maneuver occurs along a curved path. For instance, the imaged scene **32** shown in FIG. **2** may be captured while the tow vehicle **36** and trailer **38** are being backed along a curved path in a clockwise direction (i.e. the the tow vehicle **36** is steered to the left), which is manifested in the imaged scene **32** as a clockwise angular displacement of the centerline longitudinal axis **58** of the trailer **38** about point **47**. Conversely, the backing of the tow vehicle **36** and trailer **38** along a curved path in a counterclockwise direction (i.e. the tow vehicle **36** is steered to the right) is manifested as a counterclockwise angular displacement of the centerline longitudinal axis **58** of the trailer **38** about point **47**, as exemplarily shown in FIG. **3**. In either case, a hitch angle γ describes the angular displacement of the centerline longitudinal axis **58** of the trailer **38** relative to the centerline longitudinal axis **60** of the tow vehicle **36** and generally increases positively with increasing path curvature in a clockwise direction (FIG. **2**) or increases negatively with increasing path curvature in a counterclockwise direction (FIG. **3**).

With respect to the illustrated embodiment, the central region **48** is symmetric about the centerline longitudinal axis **60** of the tow vehicle **36** and encompasses hitch angle positions having relatively small hitch angles γ in both the positive and negative directions. Outer regions **50** and **52** share mirror symmetry about the centerline longitudinal axis **60** of the tow vehicle **36** and encompass hitch angle positions having greater hitch angles in the positive and negative directions than those of the central region **48**. Lastly, outermost regions **54** and **56** also share mirror symmetry about the centerline longitudinal axis **60** of the tow vehicle **36** and encompass hitch angle positions having the greatest hitch angles in both the positive and negative directions.

According to one embodiment, the outermost regions **54**, **56** of the overlay **40** are each indicative of a suggested hitch angle position limit. The hitch angle position limit is not limited to any particular hitch angle value or set of values. In one implementation, the hitch angle position limit may correspond to an operational limit of a vehicle system such as, but not limited to, a trailer backup assist system. For instance, the hitch angle position limit may encompass a maximum hitch angle γ that may be achieved by the steering system of the tow vehicle **36**. In another instance, the hitch angle position limit may encompass a maximum hitch angle γ at which a target disposed on the trailer **38** can be accurately detected by an imaging device. In yet another instance, the hitch angle position may encompass a maximum hitch angle γ before a potential jackknife condition is encountered. In any event, to provide greater visual impact, the overlay **40** may be generated as a color scale and each region **48-56** of the overlay **40** may be visually distinguished via a color associated therewith. According to one embodiment, the central region **48** may be distinguished using a green color, whereas outer regions **50**, **52** may be distinguished using a yellow color and outermost regions **54** and **56** may be distinguished using a red color. However, it should be appreciated that the overlay **40** may be represented using only the outermost regions **54**, **56**.

To enable a driver of the towed vehicle **36** to monitor the hitch angle between the tow vehicle **36** and the trailer **38**, the system **10** includes a hitch angle position indicator **62** that visually relates the current hitch angle position to the hitch angle position limit. For purposes of illustration, the hitch angle position indicator **62** is shown in FIGS. **2** and **3** as a trailer tongue but may include other visible imaged objects. When selecting the hitch angle position indicator **62**, it may be advantageous to use imaged objects that both coincide with the centerline longitudinal axis **58** of the trailer **38** and move within the overlay **40** in a consistent manner therewith. Further, if using an overlay **40** generated as a color scale, the color scale should not be so bright as to prevent a driver from seeing the trailer tongue or other imaged object serving as the hitch angle position indicator **62**.

With respect to the illustrated embodiments shown in FIGS. **2** and **3**, the hitch angle position indicator **62** coincides with the centerline longitudinal axis **58** of the trailer **38**. In this configuration, the hitch angle position indicator **62** is equidistant from each of the outermost regions **54**, **56** when the centerline longitudinal axis **58** of the trailer **38** coincides with the centerline longitudinal axis **60** of the tow vehicle **36** and is angularly displaced either towards outermost region **54** or outermost region **56** when the hitch angle γ increases in either a negative direction or a positive direction, respectively. Thus, by tracking the position of the hitch angle position indicator **62** within the overlay **40**, a driver of the tow vehicle **36** can quickly ascertain the current hitch angle position in relation to the hitch angle position limit.

Additionally or alternatively, the hitch angle position indicator **62** may be represented as a virtual object. According to one embodiment employing a color cast, the processor **16** may vary the brightness of the overlay **40** based on the current hitch angle position of the tow vehicle **36** and the trailer **38**. For example, the current hitch angle position is shown in FIG. **2** as contained within the central region **48** of the overlay **40**. In that instance, the central region **48** or portion thereof (e.g. the right half) may be made to glow brighter in color than the other regions **50-56**. Alternatively, the brightness of the central region **48** or portion thereof may remain the same while the brightness of the other regions **50-56** is reduced or eliminated altogether. In either embodiment, the processor **16** can determine in which region **48-56** the current hitch angle position is located based on hitch angle measurements supplied thereto from the hitch angle measuring device **22**, which may indicate both the hitch angle γ and heading relative to the centerline longitudinal axis **60** of the tow vehicle **36**. By using hitch angle measurements to determine the current hitch angle position, the overlay **40** may be superimposed elsewhere on the imaged scene **32**.

In the event that the current hitch angle position nears, reaches, and/or exceeds the hitch angle position limit, the processor **16** may generate a warning signal. The signal may be used to alert the driver of the tow vehicle **36** in a variety of forms. For instance, the signal may prompt a visual warning that includes flashing the outermost regions **54**, **56** of the overlay **40**. Additionally or alternatively, the signal may be sent to a vehicle audio system to prompt an auditory warning to the driver of the tow vehicle **36**. Additionally or alternatively still, the signal may prompt a haptic warning, achievable in a variety of equipment such as, but not limited to, the steering input apparatus **24**, a driver seat, and/or a smartphone or other portable electronic device.

Referring still to FIGS. **2** and **3**, the processor **16** may be further configured to superimpose a virtual steering input apparatus **64** on the imaged scene **32** that mimics the physical characteristics and behavior of an actual steering input apparatus of a trailer backup assist system such as knob **26** shown in FIG. **1**. According to one embodiment, the virtual steering input apparatus **64** is positioned on the imaged scene **32** above the overlay **40** and may include a virtual steering angle position indicator **66** that reflects the actual position of the knob **26**. As shown in FIG. **2**, the position of the virtual steering angle position indicator **66** indicates that the knob **26** has been turned counterclockwise from the at-rest position to steer the tow vehicle **36** to the left, thereby causing the tow vehicle **36** and trailer **38** to back along a curved path in a clockwise direction. As shown in FIG. **3**, the position of the virtual steering angle position indicator **66** indicates that the knob **26** has been turned clockwise from the at-rest position, thereby causing the tow vehicle **36** and trailer **38** to back along a curved path in a counter clockwise direction. Additionally, the virtual steering input apparatus **64** may indicate a steering angle position limit **68** of the knob **26**, which may be a suggested limit or correspond to one or more fixed end stops of the knob **26**, if applicable. When the steering angle position limit **68** is neared, reached, or exceeded, the processor **16** may generate a signal used to elicit a visual, auditory, and/or haptic response. It should be appreciated that a color scale similar to the one described for the overlay **40** may be used for representing a plurality of steering angle positions if desired.

Referring to FIG. **4**, a flow diagram for a hitch angle monitoring method **70** is shown, according to one embodiment. The method **70** may be embodied as a routine stored in a memory of the imaging module **12** and is executed by the processor **16**. The routine may start in step **72** when a tow vehicle **36** is placed in park or reverse. In step **74**, the camera **14** images a rear vehicle scene. In step **76**, the imaged scene **32** is displayed on a display **20** of a trailer backup assist system. In step **78**, the processor **16** superimposes an overlay **40** on the imaged scene **32** that indicates a hitch angle position limit between the tow vehicle **36** and the trailer **38**. In step **80**, a hitch angle position indicator **62** is displayed on the display **20** and identifies a current hitch angle position in relation to the hitch angle limit position. In step **82**, the processor **16** may optionally generate a virtual steering input apparatus **64** that is overlaid on the imaged scene **32** and mimics the physical characteristics and behavior of an actual steering input apparatus **24** of a trailer backup assist system. In step **84**, the processor **16** generates a warning signal when the current hitch angle position reaches or exceeds the hitch angle position limit. Once the tow vehicle **36** is placed in drive or the ignition is turned OFF, the processor **16** may end the routine in step **86**.

Accordingly, a hitch angle monitoring system **10** and method **70** have been advantageously described herein and enable a driver of a tow vehicle **36** attached to a trailer **38** to effectively monitor a current hitch angle position in relation to a hitch angle position limit.

It is to be understood that variations and modifications can be made on the aforementioned structure without departing from the concepts of the present invention, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.

What is claimed is:

**1**. A hitch angle monitoring system comprising:

a display for showing an imaged scene of a hitch connection between a tow vehicle and a trailer;

a processor configured to superimpose an overlay on the imaged scene, wherein the overlay indicates a hitch angle position limit; and

a hitch angle position indicator that is shown on the display and visually relates a hitch angle position to the hitch angle position limit.

**2**. The hitch angle monitoring system of claim **1**, wherein the hitch angle position corresponds to an angular position of a centerline longitudinal axis of the trailer relative to a centerline longitudinal axis of the tow vehicle.

**3**. The hitch angle monitoring system of claim **2**, wherein the hitch angle position indicator is one of an imaged object visible in the imaged scene and a virtual object that is overlaid on the imaged scene.

**4**. The hitch angle monitoring system of claim **3**, wherein the hitch angle position indicator coincides with the centerline longitudinal axis of the trailer and is positioned closer towards the hitch angle position limit when a hitch angle between the tow vehicle and the trailer increases.

**5**. The hitch angle monitoring system of claim **4**, wherein the overlay includes a plurality of regions, each encompassing at least one hitch angle position and each visibly distinguished by an associated color.

**6**. The hitch angle monitoring system of claim **4**, wherein the processor is further configured to generate a warning signal when the current hitch angle position nears, reaches, and/or exceeds the hitch angle position limit.

**7**. The hitch angle monitoring system of claim **1**, wherein the processor is further configured to superimpose a virtual steering input apparatus on the imaged scene that mimics the physical characteristics and behavior of an actual steering input apparatus of a trailer backup assist system.

**8**. A hitch angle monitoring system comprising:

a display for showing an imaged scene;

a processor configured to superimpose an overlay on the imaged scene that indicates a hitch angle position limit between a tow vehicle and a trailer; and

a hitch angle position indicator that is shown on the display and moves in relation to the hitch angle position limit based on a change in hitch angle between the tow vehicle and the trailer.

**9**. The hitch angle monitoring system of claim **8**, wherein the hitch angle position corresponds to an angular position of a centerline longitudinal axis of the trailer relative to a centerline longitudinal axis of the tow vehicle.

**10**. The hitch angle monitoring system of claim **9**, wherein the hitch angle position indicator moves within the overlay based on changes in a hitch angle between the tow vehicle and the trailer.

**11**. The system of **10**, wherein the hitch angle position indicator moves by way of angular displacement and coincides in position with a centerline axis of the trailer while being displaced.

**12**. The hitch angle monitoring system of claim **11**, wherein the overlay includes a plurality of regions, each encompassing at least one hitch angle position and each visibly distinguished by an associated color.

**13**. The hitch angle monitoring system of claim **11**, wherein the overlay includes a plurality of regions, each encompassing at least one hitch angle position and each visibly distinguished by an associated color.

**14**. The system of claim **8**, wherein the processor is further configured to generate a virtual steering input apparatus that is superimposed on the imaged scene and mimics the physical characteristics and behavior of an actual steering input apparatus of a trailer backup assist system.

**15**. A hitch angle monitoring method comprising the steps of:

imaging a rear vehicle scene;

displaying the imaged scene;

superimposing an overlay on the imaged scene that identifies a hitch angle position limit between a tow vehicle and a trailer; and

displaying a hitch angle position indicator that identifies a current hitch angle position in relation to the hitch angle limit position.

**16**. The hitch angle monitoring method of claim **15**, wherein the hitch angle position corresponds to an angular position of a centerline longitudinal axis of the trailer relative to a centerline longitudinal axis of the tow vehicle.

**17**. The hitch angle monitoring method of claim **16**, wherein the hitch angle position indicator coincides with the centerline longitudinal axis of the trailer and is positioned closer towards the hitch angle position limit when a hitch angle between the tow vehicle and the trailer increases.

**18**. The hitch angle monitoring method of claim **17**, wherein the overlay includes a plurality of regions, each encompassing at least one hitch angle position and each visibly distinguished by an associated color.

**19**. The hitch angle monitoring method of claim **18**, further comprising the step of generating a warning signal when the current hitch angle position nears, reaches, and/or exceeds the hitch angle position limit.

**20**. The hitch angle monitoring method of claim **19**, further comprising the step of generating a virtual steering input apparatus that is overlaid on the imaged scene and mimics the physical characteristics and behavior of an actual steering input apparatus of a trailer backup assist system.

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